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ABSTRACT

Seven microcomputer-based training systems with videotape players/monitors were installed to provide electronic counter-countermeasures (ECCM) simulation training, drill and practice, and performance testing for three courses at a fleet combat training center. Narrated videotape presentations of simulated and live jamming followed by a drill and practice session and performance test were presented to 357 trainees. The objective was to train students in electronic countermeasures (ECM) recognition in a more effective mode than can be achieved through traditional classroom lecture and textbook presentation of jamming examples. The lesson on basic jamming recognition presented training in recognizing and identifying general types of ECM. The microprocessor was programmed to (1) present the materials in response to student input through the keyboard, (2) evaluate student performance and provide feedback when appropriate, and (3) keep a complete record of all responses and response times. The results indicated a significant improvement in posttest over pretest scores, and attitudinal surveys showed a highly positive attitude toward the type of training used. The microcomputer-based training system was effective and reliable, meeting with project expectations. Future project efforts include revisions and extension of the present system. Three references are cited. (Author/CHC)

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October 1981

EVALUATION OF ELECTRONIC COUNTER-COUNTERMEASURES TRAINING USING MICROCOMPUTER-BASED TECHNOLOGY: PHASE I. BASIC JAMMING RECOGNITION

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FOREWORD

This development effort was conducted in support of advanced development project Z1177-PN (Advanced Computer-aided Instruction), subproject PN.01 (Remote Site Training Using Microcomputers), and was sponsored by the Chief of Naval Operations (OP-01). The purpose of this subproject is to conduct training research to improve electronic counter-countermeasures (ECCM) training readiness in the surface fleets.

This report is the first in a series addressing this subproject. Results are intended for officials concerned with ECCM readiness and training in the Office of the Chief of Naval Operations, Chief of Naval Material, Commander Naval Sea Systems Command, Commander Naval Electronics Systems Command, Chief of Naval Education and Training, Commanders Training Command, U.S. Atlantic and Pacific Fleets and for fleet readiness staff officers.

The outstanding cooperation of personnel of the following ships and staffs is very much appreciated: Commander Training Command, U.S. Pacific Fleet; Commander Carrier Group THREE; USS KITTY HAWK; Fleet Combat Training Center, Pacific; Commander Fleet Electronic Warfare Support Group; USS GRIDLEY; USS LEAHY; USS BERKELEY; USS LEFTWICH; Commander Joint Electronic Warfare Center; Commanding Officer, Tactical Electronic Warfare Squadron 135; and Commanding Officer, Fleet Combat Systems Training Unit, Pacific.

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SUMMARY

Problem

A requirement for improved ECCM readiness has existed for several years in the surface forces. A major problem has been lack of opportunity for radar operators to engage in interactive training where realistic jamming and chaff are used and where individuals are scored as to time and accuracy.

It is a basic premise that naval warfare will surely entail electronic countermeasures (ECM) against most sensors—including radars. Rapid and accurate electronic counter-countermeasures (ECCM) must be used to detect and track targets, a task not possible with untrained operators.

ECM, being a provocative act during peacetime, is not present in normal operations for training purposes. The exception is during fleet exercises, which provide opportunities for some operators to observe jamming and chaff. However, it appears that interactive, individual operator involvement in responsible tasks of recognition, reporting, and ECCM fix applications is lacking.

Objective

The objective of this effort was to investigate the effectiveness of microprocessor-based training systems to deliver critically needed training—both initial and refresher—to fleet operational personnel at fleet combat training centers and remote sites.

Approach

Seven microprocessor-based training systems with videotape players/monitors were installed at the Fleet Combat Training Center, Pacific to provide ECCM training. A total of 357 trainees participated in one of the following four courses: combat information center (CIC) radar jamming recognition and countermeasures, CIC watch supervisor, a special prefleet exercise course called "Readiex," and advanced operations specialist.

Narrated videotape presentations of simulated and live jamming were presented followed by a drill and practice session and performance test. The objective was to train students in ECM recognition in a more effective mode than can be achieved through traditional classroom lecture and textbook presentation of jamming examples. The lesson on basic jamming recognition presented training in recognizing and identifying general types of ECM. The microprocessor was programmed to (1) present the materials in response to student input through the keyboard, (2) evaluate student performance and provide feedback when appropriate, and (3) keep a complete record of all responses and response times.

Findings

Students showed a significant improvement in posttest over pretest scores. Attitudinal surveys showed a highly positive attitude toward the type of training used. Actual jamming displays provided the basis for much of the favorable remarks by the students. The microcomputer-based training system (including the associated videocassette equipment) was effective in providing the necessary simulation, drill and practice, and performance testing for ECCM training. The equipment down-time was very low and maintenance costs were significantly lower than anticipated.

Conclusions

1. Microcomputer-based training systems are effective for providing ECCM training for radar operators.

2. Fleet students have a highly positive attitude toward the type of training as presented by the microcomputer-based training systems during this evaluation.

3. ECCM training should include realistic simulation of jamming, chaff, and deception as it is likely to occur in combat, and performance scoring for individual time latencies and accuracy.

4. System hardware and software are reliable and meet project expectations.

Future Direction

Future project efforts include the completion of planned development and evaluation of ECCM application, an improved ECM recognition module, ECM reporting, an investigation of refresher training requirements for ECCM, and EW threat evaluation training.

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INTRODUCTION

Problem

Training radar operators to be highly proficient at rapidly and accurately recognizing and responding to incoming signals is a critical Navy requirement. In addition to target detection and tracking skills, another important set of skills is recognition of electronic countermeasures (ECM) (radar jamming) and application of appropriate electronic counter-countermeasures (ECCM). In the past, ECCM training for naval radar operators has been confined to direct, at-sea experience and limited in scope due to restrictions on types of emissions permissable during exercises. Fleet exercises are extremely costly and are scheduled on a limited basis. Moreover, fleet exercises constitute a team training type of experience often having no accountability for individual operators. There is a pressing need for development of low-cost, individualized training in ECCM.

Naval exercises conducted in 1972 by the Fleet Electronic Warfare Support Group (FEWSG) indicated an inadequate state of ECCM readiness (Pearson & Stubbs, 1975). The exercises revealed that only 60 percent of the participating ships had prior exposure to ECM. Given the advanced type of training that is received during FEWSG exercises, it appears that this type of exposure does not fully benefit inexperienced operators (40%) and may in fact serve to decrease the overall value of the exercises for the experienced operators. As a result, the Chief of Naval Material (CHNAVMAT) initiated an ECCM improvement program (project U17-64). Studies conducted as part of the CHNAVMAT project estimated that 45 percent of the surface Navy ECCM problems are training-related. Therefore, in June 1974, the Chief of Naval Education and Training (CNET) asked the Training Analysis and Evaluation Group (TAEG) to evaluate the surface Navy's ECCM readiness level. As a result of this evaluation, TAEG (Pearson & Stubbs, 1975) reported that there is essentially no viable ECCM training program in the surface Navy and recommended that the Navy Personnel Research and Development Center (NAVPERS-RANDCEN) initiate ECCM training research. The Pacific Fleet Training Command representative to the CNET R&D Advisory Group meeting in November 1977 also requested NAVPERSRANDCEN to initiate training research in ECCM. As a result, NAVPERSRANDCEN was tasked to investigate the use of computer-based simulation to provide radar operators the detailed practice required to achieve satisfactory levels of performance.

Background

ECCM is a major subdivision of electronic warfare involving actions taken to ensure the U.S. Navy's own effective use of electromagnetic radiations in spite of the enemy's use of countermeasures. It constitutes the employment of procedures, methods, and equipment technology to counter or protect against enemy use of ECM.

Since ECCM equipments supplement primary radar systems, they are not used during operations. ECCM hardware generally degrades radar performance when jamming or interference is not present; thus, it should be utilized only when absolutely necessary (i.e., when jamming or interference is present). The requirement for adequate radar system performance during routine operations, coupled with infrequent ECM encounters, have resulted in decreased practice of ECCM skills. This has been a contributing factor to the current status of ECCM readiness in the surface Navy.

Another significant contribution to the deficiencies in ECCM readiness is that the radar operator cannot develop ECCM skills on a continuing basis at the duty station. Activation of ECCM circuits on a radar system in a non-EW environment will, for the

majority of ECCM techniques, degrade the performance of the radar and do not indicate to the operator that the circuit is functioning properly. In the normal (peacetime) operating environment, the radar operator of ECCM-capable equipment will not encounter ECM, except during an EW exercise. The radar operator, because of the characteristics of his equipment, cannot "tune" the equipment (except through some limited range established by design criteria) to "find" ECM. Therefore, before he is exposed to an environment where he is expected to gain ECM/ECCM experience and learn the ideosyncrasies of his own equipment, he should be trained so that he is familiar with the types and characteristics of anticipated ECM, has had practice in detecting and identifying basic types of ECM, and has knowledge of the effect of ECM techniques on radar system performance.

Fleet radar operator personnel do not have sufficient training opportunities in recognizing types of ECM jamming nor in the application of proper ECCM techniques. Microprocessor-based videotape training systems were configured and evaluated as a means of providing individualized training in recognizing and responding to electronic countermeasures and of recording individual responses and response times.

The technological opportunities provided by such systems were investigated in an effort to address the Navy's need for small, light-weight, low-cost instructional systems and associated media. These systems can augment classroom training by providing critically needed individualized initial and refresher training for combat skills requiring hands-on training. In addition, these systems can (1) be used to support large-scale simulation trainers, (2) provide gaming environments to simulate operational problems, and (3) be deployed at remote sites for job-site training.

Previous ECCM recognition training primarily consisted of oversimplified drawings and black-and-white still photographs that were not capable of presenting the dynamic qualities necessary to train students to recognize ECM. Since signals displayed on radar scopes are highly dynamic, it appeared that the objectives of training radar operators in ECM recognition could be best satisfied by media possessing dynamic (motion) capability and synchronous audio. Additionally, a capability for rapid access to instruction in serial and nonserial fashion was a desired feature. Ease and cost of maintaining and updating perishable ECCM instructional materials were additional considerations. Videotape players with random access capability were selected as best meeting the training objectives for ECCM recognition training.

Purposes

The objectives of this research were (1) to evaluate the effectiveness of the microprocessor-based training system configured for presenting ECCM simulation training in recognizing and responding to ECM, (2) to evaluate the ECCM training developed for use on this system, and (3) to set forth follow-on needs to complete a basic upgrading of surface Navy ECCM training.

METHOD

Capabilities Needed

Based upon an analysis of the ECCM training required (Pearson & Stubbs, 1975), the following capabilities were specified for the planned training systems:

1. Presentation of microprocessor-based simulation of the types and characteristics of anticipated electronic countermeasures.

2. Drill in detecting and identifying ECM via a simulated presentation of the radar system planned position indicator (PPI) scope with individualized feedback.

3. Instruction in ECCM options, in level of effectiveness order, for countering ECM.

4. Practice in applying ECCM techniques associated with specific radar systems.

5. Individualized performance testing, including recording student response and response time.

Videotapes of simulated ECM radar jamming present enough complexity to account for significant sources of variance in the real world, while presenting basic types of ECM that are simple enough to provide practice in recognition before advancing to more complex types. Providing microprocessor-based simulation in ECCM offers the following advantages: (1) more training on different types of ECM prior to engaging in advanced at-sea exercises, (2) encouragement of student exploration of alternative responses to the various types of ECM without having to experience any possible negative consequences that might result from applying an incorrect fix; and (3) individual student feedback and monitoring. By recording the individual student's response and response time, each student's progress can be monitored. This feature addresses a TAEG finding regarding analysis of 131 FEWSG training exercise reports (covering the period 1975 to March 1980): A lack of continuity in data and reporting format made it impossible to do a meaningful ECM/ECCM statistical analysis (Pearson & Stubbs, 1980).

Preliminary Development

A substantial amount of preparatory effort preceded the development of the current effort. These efforts included: (1) orientation and familiarization of project personnel with the areas of ECCM/EW, (2) specification of training delivery system requirements and selection of equipment for the test and evaluation phase, and (3) development of an extensive ECM training media library. Details of this last effort are provided on pages 5-7 (training materials).

Training System Description

The training system consisted of a TERAK^{TM} microcomputer and a Sony Betamax video cassette tape player.[1] The TERAK, which is shown to the right in Figure 1, consists of a LSI-II microcomputer with a 56K Byte memory, a display unit, an ASCII keyboard, and two flexible disc drives. The microcomputer and video units each occupy less than 1 cubic foot and weigh approximately 40 pounds. The computer display unit is a 12-inch black-and-white monitor mounted in a free-standing pedestal base cabinet that places the horizontal center line of the display at a comfortable viewing height. The graphics display unit provides a 320-dot wide--240-dot high raster-scan display. User programs can simultaneously display both graphics and a 24 x 80 alphanumeric character array. For this application, specific keypads were covered with labels corresponding to types of jamming so that a student could rapidly enter a response to the jamming scenarios as they were displayed on the videotape monitor. The entire microcomputer system as described above is currently available for approximately $10,000. The video player, videotape monitor, and remote control unit are available for an additional $2,000.

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[1]Identification of the specific equipment is for the purpose of completeness of reporting. The Navy Department does not endorse specific products.

Figure 1. Microprocessor-based ECCM training system configuration.

A remote control unit (to the left of the keyboard in Figure 1) was used for student control of the videotape sequence. For example, a student who wanted to review a particular sequence could do so by entering the videotape counter reading start point for that particular jamming segment and then commanding the videotape player to search for it. The remote counter unit was very efficient for this purpose as it has a very rapid and accurate search capability.

The terminals were located in a classroom designated as the ECCM laboratory at the Fleet Combat Training Center, Pacific (FCTCP) (see Figure 2). The microprocessors used in this research were equipped with an additional flexible disc drive for recording student performance data and earphones were used to listen to the narrated portion of the videotapes.

Training Materials

The materials were designed to train students to perform their jobs as surface ship radar operators in an ECM environment. Radar jamming recognition and ECCM fix applications are crucial to performance of this task. Training for the terminal goal behavior of target detection and tracking by clearing or partial clearing of the radar scope was divided into four lessons: basic jamming recognition, two advanced jamming recognition lessons, and ECCM fix application. This report covers only the evaluation of the basic jamming recognition lesson. Advanced jamming recognition lessons for the AN/SPS-10 and AN/SPS-43 radars and the ECCM application lessons are currently being evaluated and will be reported on in FY82.

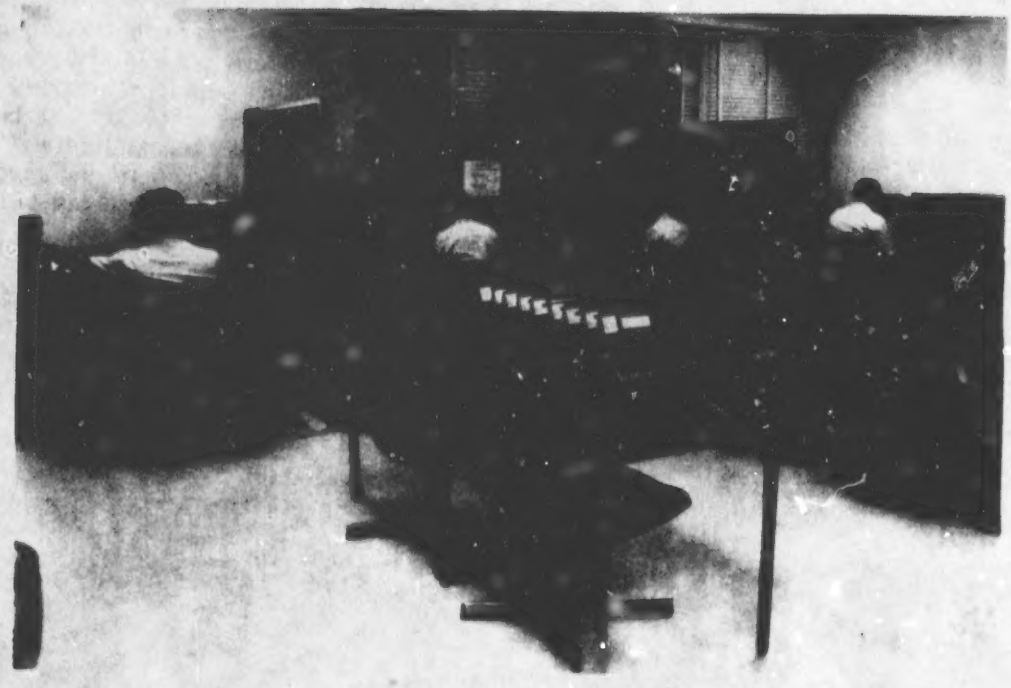

Figure 2. ECCM laborator, at FCTCP.

Development of Training Media Library

Extensive videotaping of simulated and live jamming was accomplished with the assistance of tactical EW squadron VAQ-35 and Fleet Combat Systems Training Unit, Pacific personnel, and involved many days of shipboard taping and in-port exercises. In-port ships employed were USS LEAHY (CG 16), USS GRIDLEY (CG 21), and USS BERKELEY (DDG 15). At-sea ships were USS KITTY HAWK (CV 63) and USS LEFTWICH (DD 984). In-port ECM was simulated by injecting signals into the intermediate frequency (IF) strip of air and surface search radars by the MPQ-T1 Pierside Trainer, a mobile van capable of stimulating multiple sensors aboard surface ships.

Additional videotaping of radar-specific ECM/ECCM scenarios has been an ongoing task of the project. Obtaining appropriate tapes has been difficult because the fleet is often engaged in other types of exercises. Thus, videotapes were obtained whenever there was an opportunity that did not interfere with scheduled exercises.

Basic Jamming Recognition Lessons

The lesson on basic jamming recognition was designed to train students to recognize and identify general types of radar ECM. Materials were presented to students on the computer and videotape player and monitor and included an introduction to the microprocessor-based training system, a pretest, instructions, drill and practice with individualized feedback, and a posttest. The microprocessor was programmed to (1) present these materials in response to student input through the keyboard, (2) evaluate student performance, and (3) provide feedback when appropriate.

Radar PPI monitor displays were presented to students on three videotapes (A, B, and C), which the student was guided through via instructions presented on the microprocessor. Tape "A" presented a 20-minute narrated sequence of various examples of basic jamming types with information concerning details and means of distinguishing between the different types (e.g., FM pulse versus synchronous pulse). Two jamming segments were shown on each scope display and each jamming segment included three sectors--a main lobe and two side lobes. These segments were presented at 000° bearing and 180° bearing. An example is shown in Figure 3. Each lobe was approximately 20° wide with an average sector of 15° between lobes so that the upper segment included that portion of the PPI scope between 300°-035° and the lower segment spanned the 130°-245° portion.

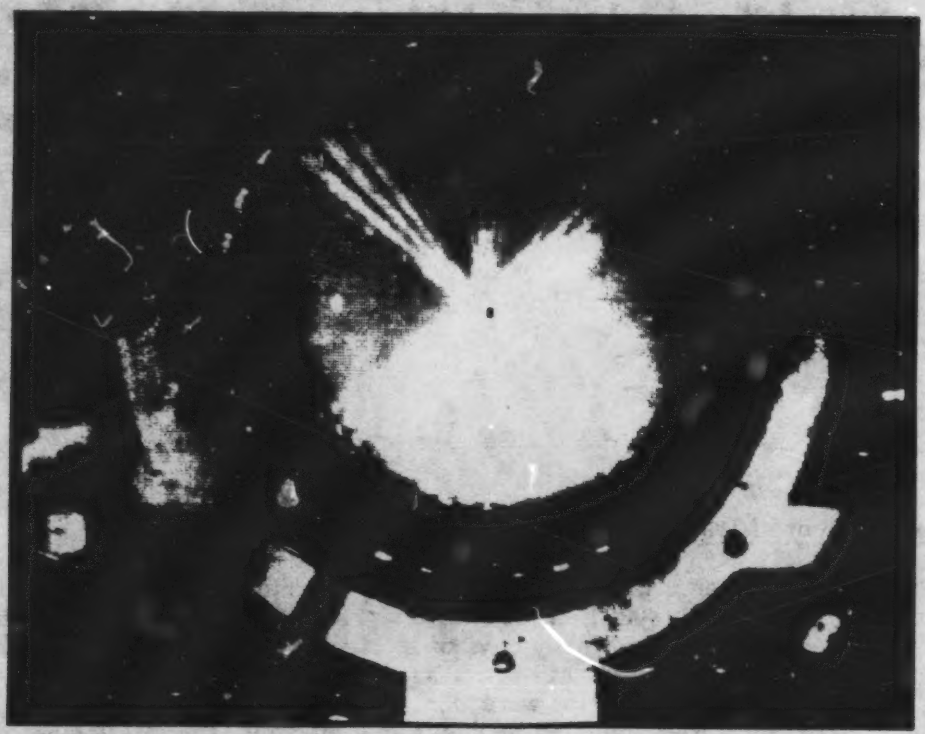

Figure 3. Videotape of jammed radar PPI scope.

Five targets were presented, one each at bearings 000°, 030°, 180°, 240°, and 270° to illustrate the effects of jamming on the operator's ability to see targets. Each pair of jamming segments was shown for five PPI radar scope rotations or approximately 60 seconds. Nine types of jamming were used: noise, AM noise, FM noise, swept noise, asynchronous pulse, FM pulse, swept synchronous pulse, synchronous pulse, and no jamming.

The type of information presented in a lesson included statements intended to assist the student in learning to distinguish among various jamming types. These statements were included on the audiotrack of the videotape when a contrasting example of jamming was shown. In this first ECCM training development effort, the videotape player and monitor were not interfaced with the computer. (See the recommendations section of this

report for a discussion of the need to interface the videotape player with the micro processor.) To ensure coordination of viewing and responding to the proper jamming sequence, the computer presentations for all three videotapes indicated the beginning and ending remote counter readings and the bearing for the jamming sequence that the student was to view and identify.

Drill and practice (Tape B) presented 42 examples of the nine basic jamming types. Rapidity and accuracy were stressed as major objectives during the training. The student was to identify the jamming by pressing one of a group of specially marked keys on the keyboard.

The posttest (Tape C) consisted of the same 42 jamming signals presented in a randomized order. A percentage score and mean response time in seconds were displayed at the completion of both drill and practice and the posttest.

Subjects

A total of 357 (fleet) trainees participated in this research effort. All students assigned to the following four courses received the microprocessor-based ECCM training: combat information center (CIC) radar jamming recognition and countermeasures, CIC watch supervisor, a special prefleet exercise course called "Readiex," and advanced operations specialist (OS).

Procedure

Seven microprocessor-based ECCM training systems were available for student use. A total of 23 classes participated in the computer-based ECCM training (March 1980-April 1981) as part of the four courses mentioned above. Class enrollment ranged from 8 to 23 students; 7 students at a time were run until all completed the training. The course instructor lectured informally to those students who were waiting to engage in the simulation training.

Each student signed on to the system and began to proceed through the materials. The basic jamming recognition lesson had an orientation to the microprocessor-based system that required approximately 10 minutes and an eight-item pretest that preceded the three training tapes. Students were encouraged to go through each videotape as many times as needed to become proficient before advancing to the next tape in sequence. Following the microprocessor-based training, all students responded to the student reaction questionnaire. The instructors wanted all students to receive the simulation training. Since time limitations did not allow a counter-balanced design, there was no control condition. Effectiveness was determined by changes in pretest-posttest scores.

The computer presented the material, monitored student performance, and kept a complete record of all responses and response times. Students were required to complete the training segments in sequence: pretest, narrated training tape, drill and practice, and performance test. While scores received on drill and practice did not contribute to the student's grade for the laboratory portion of the complete course, scoring high on the drill and practice portion of the training was generally a prerequisite for receiving a high score on the posttest. Thus, most students who scored low on drill and practice were motivated to seek help from a proctor or instructor and to repeat the drill and practice portion of the training until they attained a reasonably high score.

The laboratory portion of each of the four courses was meant to supplement the regular curriculum taught by the instructor; specifically, to train students in ECM

recognition in a more effective mode than can be achieved through traditional classroom lecture and textbook presentation of jamming examples. The regular ECCM and the advanced operations specialist course students received approximately 20 hours per student of lab time on the systems. This lab consisted of basic ECM recognition (narration, drill and practice, and performance testing) and radar-specific advanced ECM recognition (with narrated tapes, drill and practice, and performance testing). The CIC watch supervisor course students received approximately 7 hours in basic ECM recognition training. The special course for Readiex training consisted of about 7 hours of combined basic and advanced, radar-specific ECM recognition.

Analysis

To assess whether the microprocessor-based training resulted in improved ECCM capabilities, statistical analyses were performed utilizing pre- and posttest scores for students participating in the four different courses offered at FCTCP. The major question posed in these analyses was whether participation in the training program significantly improved the students' ECCM recognition ability. This question was addressed through analyses of differences between pretest and posttest scores. A second, related question was whether improvement occurred regardless of initial differences in performance in the four classes.

RESULTS AND DISCUSSION

Student Experience

Table 1 presents rates of students who participated in ECCM, watch supervisor, Readiex, and advanced OS courses. As shown, the students represent an ascending scale of experience levels in the OS rating (i.e., from OSSA to OSC) as well as various levels in the electronic warfare technician (EW), electronics technician (ET), and fire control technician (FT) ratings. Also, one officer (ensign) participated in the watch supervisor course. The differences among experience levels in these grades would be expected to include ECCM and general CIC fleet experience that, in turn, could affect pretest and subsequent posttest performance scores.

Table 2 reveals the types and amount of previous ECCM experience for students in the four different courses. The lack of ECCM readiness is indicated by the fact that 66 percent (N = 235) of the students had no prior ECCM training and the remaining 34 percent had very little to some exposure to fleet exercises, as shown in Table 2. The formal training in ECM recognition received in the four courses ranged from 7 hours in watch supervisor and Readiex courses to 20 hours in the ECCM and advanced OS courses.

Performance Scores

Table 3 presents the means and standard deviations (SDs) for performance scores for pretest, drill and practice, and posttest portions of the basic jamming recognition training for the four classes. Posttest means are consistently high and are grouped much closer together than pretest means. The reduced SDs on the posttest also indicate more homogeneous performance within groups after training.

A one-way analysis of variance indicated that the classes differed significantly on both the pretest ($p < .01$) and posttest ($p < .05$). Tukey's post-hoc test of differences was performed on pretest and posttest scores to identify the differences between the four courses. Table 3, which provides results, shows that students in the ECCM, special

Table 1

Rate Distribution of ECCM Students by Class

	Number of Students				
Rate	ECCM	Watch Supervisor	Readiex	Advanced OS	Total
OSSA	12	2	0	0	14
OSSN	40	17	2	0	59
OS3	59	69	6	6	140
OS2	35	40	9	17	101
OS1	5	14	0	1	20
OSC	0	0	1	2	3
EW3	4	1	0	0	5
EWC	0	1	0	0	1
ET1	0	1	0	0	1
FTM2	4	0	0	0	4
ENS	0	1	0	0	1
Total	159	146	18	26	349

Note. The table reflects totals for the 349 students who completed the student questionnaire.

Table 2

Students' Previous ECCM Training

Type of Previous ECCM Training	Number of Students by Class				
	ECCM	Watch Supervisor	Readiex	Advanced OS	Total
None	113	102	2	18	235
Read publications aboard ship	3	0	0	0	3
Little	20	9	1	1	31
Observed some live jamming	1	0	0	0	1
Advanced team training	2	0	0	0	2
Passive scope observation	5	10	2	0	17
Fleet exercises:					
WESTPAC cruise	5	5	0	0	10
Jamex (jamming aircraft & simulators)	19	9	2	4	34
Samex (at sea)	0	1	0	0	1
Schools:					
OS "A"	0	1	1	0	2
Advanced OS course	2	0	0	0	2
EW "A"	2	1	0	0	3
Watch supervisor	6	0	1	1	8
ECCM course	0	5	0	1	6
Air intercept controller	0	0	1	0	1
Total	178	143	10	25	356

Note. The table reflects totals for the 356 students who completed questionnaire.

Table 3

Means and Standard Deviations for Percentage Scores on Basic Jamming Recognition Lesson

Class	Pretest Mean	Pretest SD	Drill/Practice Mean	Drill/Practice SD	Posttest Mean	Posttest SD
ECCM	38.45 (N = 139)	32.43	79.10 (N = 162)	15.24	83.13 (N = 165)	13.47
Watch Supervisor	22.19* (N = 122)	25.60	73.68 (N = 139)	17.92	83.77 (N = 139)	13.82
Readiex	48.60 (N = 5)	39.20	70.77 (N = 13)	24.07	87.75 (N = 12)	17.15
Advanced OS	43.56 (N = 27)	30.19	83.54 (N = 28)	12.57	91.48** (N = 29)	8.13

Notes.

1. Pooled variance was 879.75 (df = 289) for the pretest and 179.73 (df = 341) for the posttest.

2. Students with missing data for pretest or posttest were excluded from the analysis.

*Significant difference from other three classes on pretest.
**Significant difference from ECCM and watch supervisor classes on posttest.

Readiex, and advanced OS courses entered training with significantly greater demonstratable ECCM recognition ability than did the students in the watch supervisor course. On the posttest, the ECCM and watch supervisor groups performed significantly lower than did the advanced OS group. These differences seem to be reflective of the higher ratings and longer length of service of the students in the Readiex and advanced OS Courses (see Table 1). The proportion of less experienced personnel (OSSA, OSSN, OS3) was much greater in the ECCM and watch supervisor courses (66%) compared to the Readiex and advanced OS courses (32%)

An analysis was made of the difference between pretest and posttest scores to determine whether the instruction produced an improvement in performance. Table 4 shows the pretest-posttest mean difference scores, their SDs, and t-tests of the significance of each difference. The t-tests used a pooled estimate of error since there was homogeneity of variance among the four groups. Results indicate that, within each group, there was a substantial and significant gain in performance from pretest to posttest. Thus, the training seems to be highly effective in all classes despite large differences in entering ability.

Table 4

Differences Between Pretest and Posttest Scores

Class	N	Mean Difference	SD	t
ECCM	133	46.42	32.04	17.83*
Watch Sup	115	57.44	27.46	20.51*
Readiex	4	57.75	35.20	3.45*
Advanced OS	27	48.67	29.57	8.42*

Note. Students with missing data for pretest or posttest were excluded from the analysis.

*p < .01 (pooled variance = 901.55, df = 275).

Response Time

Response time was defined as the number of seconds required from the initial presentation of a jamming segment until the student entered and recorded a response. There were two jamming types per display (000° and 180° bearing) and the student had to identify each. The clock was reset after the first response.

Mean response times presented in Table 5 reveal a marked reduction in mean response time from pretest to posttest and in SDs. It took about 40 seconds for the student to identify both ECM presentations on a display. This 40 seconds includes about 6 seconds average waiting time for the video tape to access the display. Since each sweep of the radar takes 12 seconds, students require less than two sweeps to identify a single instance of jamming on the posttest.

Table 5

Means and Standard Deviations for Basic Jamming Recognition Response Time in Seconds

Class	Pretest		Drill/Practice		Posttest	
	Mean	SD	Mean	SD	Mean	SD
ECCM	29.22 (N = 139)	12.35	22.11 (N = 162)	6.37	20.83 (N = 165)	7.56
Watch Supervisor	29.01 (N = 121)	13.79	22.60 (N = 139)	6.58	20.04 (N = 138)	4.94
Readiex	28.00 (N = 5)	12.90	27.54 (N = 13)	8.93	18.50 (N = 12)	5.63
Advanced OS	26.11 (N = 27)	8.02	20.54 (N = 28)	4.83	21.31 (N = 29)	6.10

Student Acceptance

Responses to the student questionnaire indicated that student attitudes were quite favorable towards the ECCM training. They liked the TERAK system, the training materials, and the mode of instruction. Specifically, students made positive comments about the hands-on experience and the opportunity to observe actual jamming sequences. "Being able to actually see jamming on the scope while hearing what type of fix was being used is an immense help in learning this material" is indicative of a typical student's response.

In responding to the question regarding specific aspects of training liked most, 91 percent of the students listed using the computer and 53 percent replied that seeing jamming was extremely helpful ("one of the best Navy courses I have had in 2½ years"). Other noteworthy responses to this question included the use of the keyboard (being able to push buttons), and the chance to actually apply theory and make judgment calls.

Students reported that the ECM/ECCM training was extremely helpful and felt that it would enhance their performance in the operational setting. In responding to why they felt the training was or was not effective, the following comments typify the responses made by 86 percent of the students: "I had never seen jamming before, things like this are not available in the fleet" and "the videotape simualtions were much more realistic than drawings or talking about jamming." Some of the characteristics students reported they liked most about the microprocessor-based training were the immediate feedback, the emphasis on basics, self-paced study, and the fact that the microprocessor was fun and easy to operate. The following statement summarizes the reactions of the majority of students: "It presented what you need to see to get a complete understanding of ECCM." Criticisms of the training included the lack of training in fix application, the need for more time on the system, the difficulty at times in distinguishing between two types of jamming, and the need for improving the photography in some cases.

When asked how much the videotape simulations of the radar scope aid in learning as opposed to using a workbook, 72 percent felt the simulated presentation was far superior. A typical comment was: "Pictures do not compare to actual video; videotapes are a lot more realistic." Students also expressed a liking for being able to view two types of jamming on the same scope, which made it easier to remember differences between types. Furthermore, students stated that it was easier to get involved and to comprehend the material in a videotape format.

In response to a question asking to what extent they felt the new training mode helped their understanding of all basic ECCM skills, 92 percent replied "to a great extent" or "to a very great extent." When asked to compare this microprocessor-based training with other methods of learning, 100 percent rated it as enjoyable or very enjoyable. When rating microprocessor-based training in relation to other training they have experienced, 79 percent rated it as "outstanding," with the remaining 21 percent rating it as "above average." All of the students felt that the feedback provided on their performance during drill and practice was an effective aid to learning. Ninety-three percent reported that the training will be very effective in enabling them to recognize basic types of ECM in the fleet.

CONCLUSIONS

The use of a microprocessor-based training system for providing ECCM simulation is a feasible methodology for ECCM training. The system afforded students the opportunity

to observe and respond to various jamming scenarios. Overall indications from objective performance scores and from student and instructor reactions were that the training system was very effective for training the "hands on" portion of the ECCM course. Microprocessor-based training provides a valuable addition to the established ECCM course. Fleet school instruction personnel judge the microprocessor-based training systems capable of functioning on a stand-alone basis as they were designed to do. Implementation of microprocessor-based training systems at fleet schools and at remote sites would give radar operators access to interactive training that has not previously been available through fleet exercises, traditional classroom instruction using insturctional texts with still photographs, or any sort of on-the-job training. Successful implementation of such a system should lead to improved ECCM performance capabilities while requiring minimal capital investment. Much of the necessary training in ECM recognition and ECCM can be accomplished through systems similar to the low-cost system reported on here without the need for high cost simulators.

FUTURE DIRECTION

Beyond implementing lessons that have been developed to date, further development will include the following extensions to the existing lessons: (1) revision of current lessons to augment their training effectiveness, (2) interfacing the videotape player with the microprocessor, (3) establishing time and accuracy criteria for operator performance, and (4) determining optimal sequencing for operator refresher training.

Revision of the present lessons would involve presentation of ECCM effects from both a simulated and cognitive perspective. For example, the rationale for employing a particular ECCM type would be presented on the computer monitor while examples of simulated presentations depicting the effects are shown.

Interfacing the videotape player with the microprocessor to bring the selection and presentation of videotape segments under computer control would provide several advantages. Computer control of videotape presentations would result in an automatic, and thus, more rapid, presentation of video segments. In addition, computer control of video presentation would provide optimized sequencing of particular video segments (e.g., for review purposes) and therefore better individualized instruction. At this time, a computer interface for the Terak microprocessor is not available but a low-cost interface is now being developed (in-house) and is expected to be in use by about November 1981.

Student accountability must be incorporated into the overall ECCM improvement plans. A precise definition of ECCM personnel performance objectives for the OS and FT ratings is needed so that training goals can be firmly established. The microprocessor-based training system facilitates individual student accountability by enabling the student to practice ECCM skills until an acceptable level of performance is achieved.

Schendel, Shields, and Katz (1978) conclude that proficiency of basic combat training skills cannot be maintained in the absence of regular practice. ECCM skills are highly perishable and refresher training will be necessary to maintain readiness. ECCM operational skills involve a complex configuration of task elements, which include identification, classification, and procedural skills. An important area for future research involves determination of the frequency, type, and amount of refresher training required to maintain previously attained skill levels.

RECOMMENDATIONS

1. Microprocessor-based training systems should be implemented for ECCM training. Extensive use of microprocessor-based simulation training at fleet schools and remote sites should make a significant impact on closing the gaps between training requirements and current training capabilities. A future area for research would involve a feasibility study of whether a lower-cost (approximately one-third the cost of the Terak) and slightly less powerful microprocessor would meet the requirements for providing ECCM training.

2. Additional radar specific ECCM training media (e.g, videotapes) and computer-based lessons to continue to increase the materials required to provide initial and refresher training should be developed. Performance training cannot be effectively accomplished in the absence of appropriate ECM (actual or synthetic).

3. Students who have received initial ECCM training should be tracked to determine skill loss, determine optimal sequencing, and initiate schedules for ECCM refresher training. After initial ECCM training at Fleet Combat Training Centers, Atlantic/Pacific, refresher training could be conducted at locations where Fleet Training Groups are present.

4. ECCM application lessons designed to train students in ECCM types and options in level of effectiveness order for countering ECM should be developed and evaluated. These lessons should include practice in applying ECCM techniques associated with specific radar systems and individualized performance testing.

5. Feasibility tests for implementing microprocessors and ECCM training at remote sites should be conducted.

6. An ECM reporting lesson and an EW threat evaluation lesson should be developed and evaluated.

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